THE INTERSECTION OF THE SUPPLY CHAIN AND TRANSPORT DOMAINS

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ABSTRACT

The supply chain domain and the transport domain intersect whenever there is an item in a supply chain that shall be moved from one place to another, e.g. from a factory to a warehouse or from a retailer to a customer. The supply chain domain and the transport domain have their own models for the operation of their respective systems and they use different terms and terminology. The main objective of this paper is to describe the intersection of the two domains to have a better understanding of the different terms and models used and a common view on the upper level of the system architecture in both domains focusing on the main roles and responsibilities. The supply chain domain is described by the SCOR model (Supply-Chain Operations Reference-model) [1] and the transport domain is described by ARKTRANS [2]. This paper describes how the SCOR operation reference model is transformed to a role model being comparable with the ARKTRANS model. It also describes how the supply chain roles could be defined as the Transport User role in the transport domain. Finally the paper describes an information architecture on a high (but not complete) level.

KEYWORDS

Intelligent Transport System, Intelligent Goods, Role model, Supply chain, System architecture, ARKTRANS

INTRODUCTION

The supply chain domain and the transport domain intersect whenever there is an item in a supply chain that shall be moved from one place to another, e.g. from a factory to a warehouse or from a retailer to a customer. By Transport domain it is meant any publicly available transport system, e.g. a road or a rail network used for transport of persons and/or goods, including its services and information flows. The terminals may also be seen as part of the transport system, e.g. a publicly owned and operated harbour terminal.

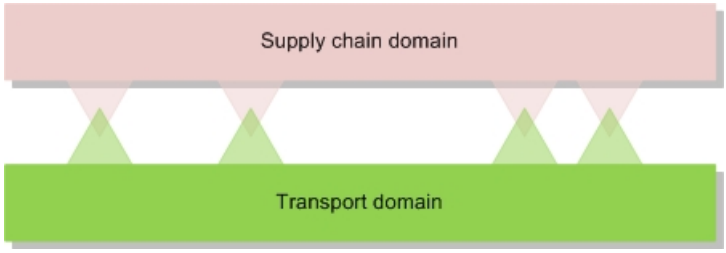

Figure 1: Intersections between the supply chain domain and the transport domain

The supply chain domain and the transport domain have their own models for the operation of their respective systems and they use different terms and terminology. The main objective of this paper is to describe the intersection of the two domains to have a better understanding of the different terms and models used and a common view on the upper level of the system architecture in both domains focusing on the main roles and responsibilities. The intersection description will also be used as a basis for a more detailed analysis of the different system requirement to a transport system for intelligent goods.

The supply chain domain is described by the SCOR model (Supply-Chain Operations Reference-model) [1] and the transport domain is described by ARKTRANS [2].

SCOR is the product of the Supply-Chain Council which is an independent, not-for-profit, global corporation with membership open to all companies and organisations interested in applying and advancing the state-of-the-art in supply chain management systems and practises. ARKTRANS is a reference model for transport systems seen from a role model, functional and informational point of view. The system architecture is independent of transport modes and may be applied for any transport system. ARKTRANS is developed and maintained by ITS Norway and SINTEF.

INTRANS is a Norwegian research project with main focus on intelligent goods in intelligent transport systems. The project includes both the supply chain domain and the transport domain and is funded by the Research Council of Norway.

THE SCOR MODEL

The SCOR model covers the complete supply chain from order entry to paid invoice and may involve many different units within a complete supply chain. The model is based on 5 core management processes: Plan, Source, Make, Deliver and Return. These management processes are found in each of the units in the supply chain (except the first and last unit).

The Figure 2 shows an example on a 5-unit supply-chain and represents the top level of the SCOR model with its types of processes.

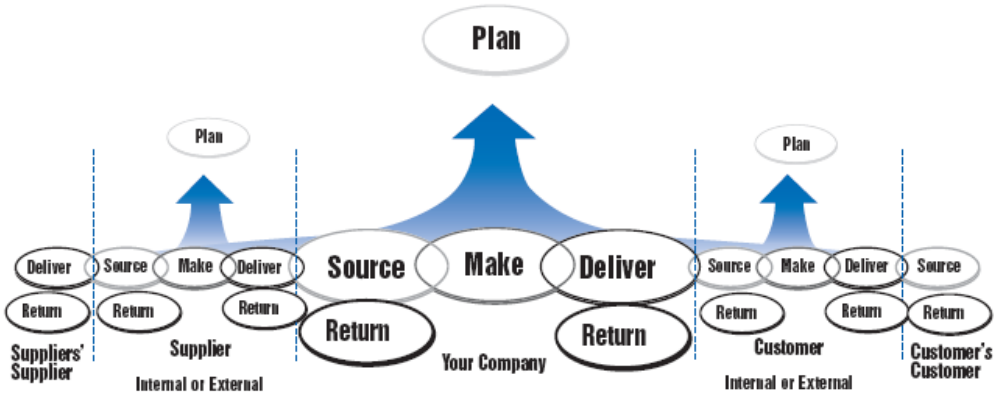

Figure 2: The SCOR model – top level view (Source: [1]**)**

The model in Figure 2 can be generalised to cover any unit in the chain, see Figure 3. The model will be valid independent of whether the unit in question is a supplier, a supplier's supplier, a producer, a customer or a customer's customer. The main physical interface between two units will always be between the processes Deliver – Source and Return – Return and this is where the supply-chain intersects with the transport world from a functional point of view. However, from an information point of view all the SCOR processes will have an interface with the transport world. This is explained later in this document.

The core process **Plan** covers demand and supply planning and management including amongst others plans for the whole supply chain, including Return and the execution processes Source, Make and Deliver. In relation to transport it will be the plans for the processes Source, Deliver and Return that will be the crucial processes. The management part of the Plan process will also include the supply chain transportation.

The core process **Source** covers sourcing for different types of products, e.g. stocked, make-to-order and engineer-to-order. The process is the counterpart to the Deliver process of a unit upstream of the supply chain and has an interface to the transport world in those cases where the Deliver process uses a publicly available transport system.

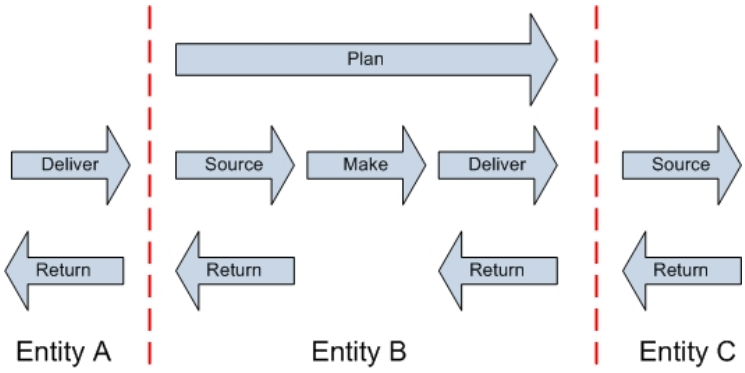

Figure 3: The generalised SCOR model

The core process **Make** covers mainly production, testing and packaging of products to be transferred to the Deliver process. The process has minimal physical or information interface to the transport domain.

The core process **Deliver** covers all order management steps from processing customer inquiries to routing shipments and selecting transport service providers. It also covers warehouse management, e.g. receiving and picking products to load and shipping products. The process Deliver is probably the SCOR process that is most relevant concerning the intersection between the supply chain domain and the transport domain as the process has an obvious interface to the transport domain.

The core process **Return** covers two subtypes of Return processes, - one is linked to the Source process and one is linked to the Deliver process. The processes cover both Defective products, Maintenance-Repair-Overhaul products and Excess products. It is the Source Return process that is most relevant for the intersection between the supply chain and transport domain as this process covers scheduling the shipment and returning the product upstream in the supply chain. However, the Deliver Return process will also in some cases be part of the intersection between the supply chain domain and the transport domain as the process covers both the receiving of the product and further transfer of the product.

TRANSFERRING THE SCOR PROCESS MODEL TO A ROLE MODEL

The SCOR model is a process oriented model while the ARKTRANS model is, on its highest logical level, a role model where the different responsibilities of each role are reflecting the processes in the transport system. In order to compare the two models and to describe the intersection in a consistent way, the two models should be described in the same 'language'. In this paper the SCOR model has been transformed to a role model where the responsibilities of each role are reflecting the processes in the SCOR model. To simplify the role model, only the transport related responsibilities of the role have been included. The relevant SCOR process is referenced for each responsibility enabling a mapping between the process model and role model. The name of the roles has been chosen to be as close as possible to the name of the relevant core process but the name is also supplemented with other terms that explains the role and describes organisations or persons that may perform the whole or parts of the role.

The **Planner** role covers the responsibilities related to the Plan processes in the SCOR model. Supply chain manager may be another term that could describe the role. The following transport related responsibilities are seen as being part of the Planner role:

- Specify Source requirements related to transport and establish Source transport plans (parts of SCOR P2.1-4)
- Specify Deliver requirements related to transport and establish Deliver transport plans (parts of SCOR P4.1-4)
- Specify Return requirements related to transport and establish Return transport plans (parts of SCOR P5.1-4)

The **Purchaser** covers the responsibilities related to the Source processes. Other terms that may describe this role are Acquirer, Customer and Consignee. The following transport related responsibilities are part of the Purchaser role:

- Implement the Source transport plans
- Schedule Product Deliveries (SCOR S1.1)
- Receive Product (SCOR S1.3)

The **Producer** (Maker, Manufacturer) as defined in SCOR is not seen as relevant for the intersection between the supply chain domain and the transport domain.

The **Deliverer** covers the responsibilities related to the Deliver processes. The Deliverer's role may also be described by terms like the Supplier, Provider and Consigner. The list of responsibilities related to the Deliverer includes:

- Implement the delivery transport plans
- Determine delivery date (part of SCOR D1.3 and D2.3), consolidate orders and build loads (SCOR D1.4-5, D.2.4-5 and D3.5)
- Route shipments and select transport service providers (carriers) and rate shipments (SCOR D1.6-7, D2.6-7 and D3.6-7)
- Pack product, load product and generate shipping documents (SCOR D1.10-11, D2.10-11 and D3.10-11)
- Ship product (SCOR D1.12, D2.12 and D3.12)
- Receive and verify product by customer (SCOR D1.13, D2.13 and D3.13)

The **Returner** covers the responsibilities related to the Return process. The Returner role may also be described by terms like Consigner (Source Return) and Consignee (Deliver Return), Customer (Source Return) and Supplier (Deliver Return). The responsibilities related to the role are:

- Implement the Return transport plans
- Schedule Product shipment (SCOR SR1.4, SR2.4 and SR3.4)
- Return Product (SCOR SR1.5, SR2.5 and SR3.5)
- Receive Product (SCOR DR1.4, DR2.3 and DR3.3)

THE ARKTRANS ROLE MODEL

The ARKTRANS roles described below are defined in ARKTRANS [2] and used in the EU project SMARTFREIGHT [3] which is a research project co-funded by the European Commission under the Seventh Framework Programme for R&D, Theme 3 'Information and Communication Technologies'. The SmartFreight project has the following main goals:

- Develop new traffic management measures towards individual freight vehicles through open ICT services, on-board equipment and integrated wireless communication infrastructure
- Improve the interoperability between traffic management and freight distribution systems
- Coordinate all freight distribution operations within a city by means of open ICT services, on-board equipment, wireless communication infrastructure and CALM MAIL implementation in on-board and on-cargo units, for all freight vehicles

The ARKTRANS role model proposed for the INTRANS project includes the same roles as defined in the SmartFreight project [4].

The role **Transport Network Manager** is responsible for the management of the physical transport network infrastructure, e.g. a road network, including:

- Planning, establishment, operation, maintenance, etc. of the physical transport network infrastructure including the equipment needed for the network operation.
- Management of information about the physical transport network infrastructure, e.g. the status of a road section.

The role **Traffic and Transport Planner** is responsible for the strategy on traffic and transport issues in an area including:

- The assessment of possible solutions and resulting impacts, e.g. by means of traffic modelling and impact evaluations.
- Decision of the overall policy for the traffic management, for example the use of low emission zones, the service classes to be assigned in certain traffic situations and the accessibility for different types of transport users, e.g. transport of goods

The role **Transport Network Resource Manager** is responsible for the assignment of transport network resources to vehicles, e.g. loading and unloading areas, parking areas and waiting areas. Examples of this role are a city council, a road administration or a terminal operator managing the assignment of resources like loading and unloading areas

The role of the **Traffic Manager** is responsible for the following issues:

- The best possible traffic flow during normal and abnormal traffic and infrastructure conditions through efficient traffic management and incident handling, e.g. by controlling the infrastructure and by guidance or orders given to the drivers.
- The management of information about the traffic and infrastructure condition and provision of such information to those needing it.
- Monitoring the access to specific areas or transport network resources and detection of access violations.

The **Transport User** role, as defined in ARKTRANS, is the originator of any transport service request (including traffic information services) and has the following responsibilities:

- Defining the transport demands and requirements including the object, e.g. the cargo item, to be transported
- Transport planning and re-planning (finding the best transport alternative, i.e. the best transport services)
- Transport follow up, e.g. track and trace an object in the transport system

The Transport User is a crucial role in a transport system. In real life, the responsibilities of the Transport User may be split between different persons, companies or organisations. For instance, the responsibility for defining the transport service may be performed by a company making a product, the transport planning may be performed by a forwarding agent (acting as a Transport User) and the transport follow up may be performed by the company making the product (consigner and main responsible). The transport follow up may also be performed by

the Customer of the product, not necessarily as a responsibility (which should only be allocated to one entity) but as a possibility.

The **Transport Service Manager** is responsible for handling the transport user requests:

- Planning of the transport and information services to be provided based on the transport user requirements
- Provision of transport services, e.g. the transport of cargo from one point to another, loading, unloading, reporting to authorities, etc.
- Provision of required status information to the Transport User during the transport in those cases where this information is not available to the Transport User by other means.

The **Transport Operation Manager** (dispatcher) is responsible for the management of transport related operations required for the provision of transport services. The transport related operations may be provided by transport means or at pick-up/delivery locations and at terminals. A freight distribution centre would be an example of a Transport Operation Manager.

The **Transport Operation Worker** is responsible for the actual execution of the transport related operations (e.g. reporting operations or cargo handling operations like loading, unloading, transhipment) according to instructions from the Transport Service Manager.

The **Driver** is responsible for:

- The steering and/or control of the vehicle.
- Adaptation to the traffic situation in a way that ensures safety and contributes to efficiency.

The terms Driver and vehicle may be replaced with other terms, e.g. captain and vessel.

In the ARKTRANS reference model the transport domain is divided into sub-domains based on relationships between responsibilities, groups of responsibilities and focus areas. Each of the roles described above are linked to an ARKTRANS sub domain in Figure 4.

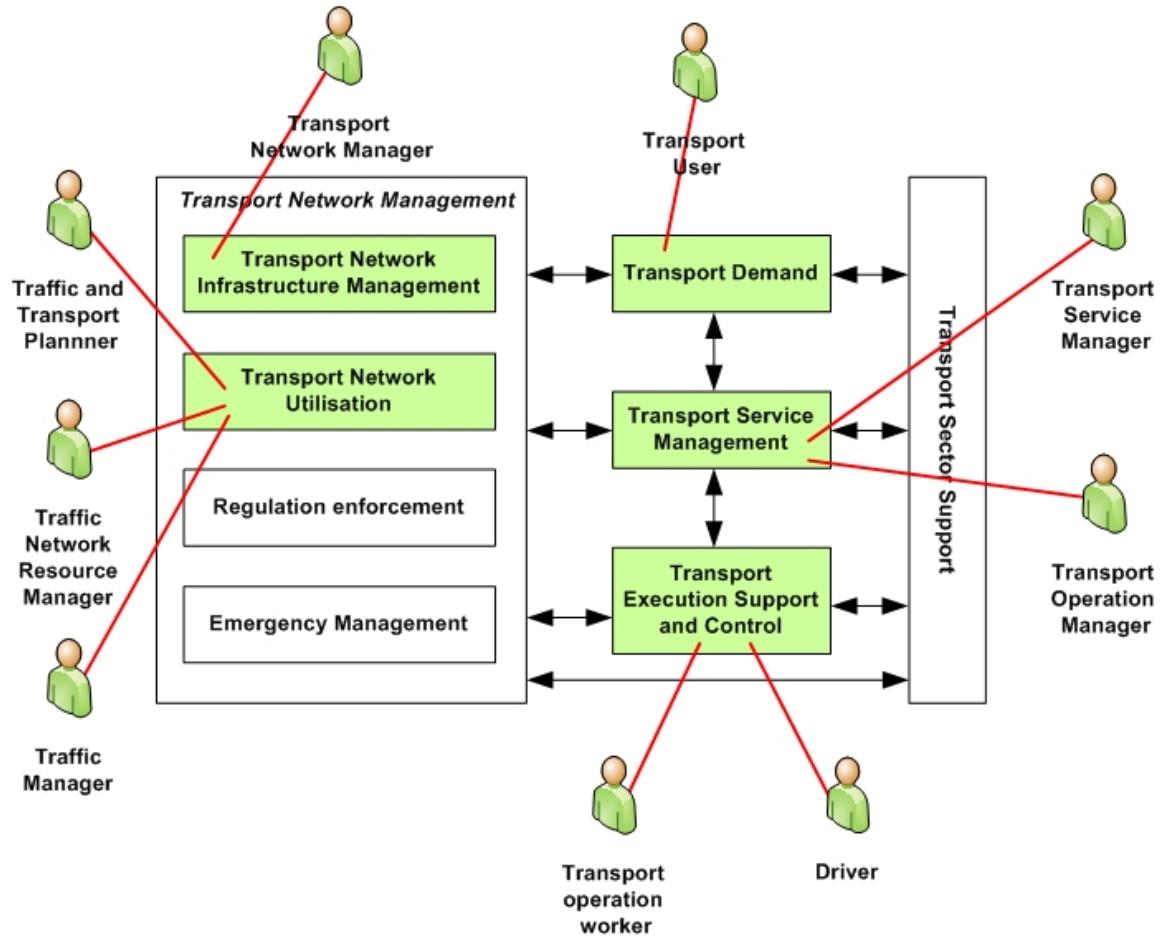

Figure 4: ARKTRANS roles linked to the ARKTRANS sub-domains

THE ROLE OF THE INTELLIGENT GOODS

In the INTRANS project the intelligent goods has a major role which covers the following responsibilities in its most enhanced version:

- Store and protect information linked to the goods and its transport from A to B, e.g. unique identity, special characteristics (e.g. highly inflammable), origin-destination data and alternative routes
- Monitor the transport from A to B e.g. sending an alarm when the temperature exceeds a certain limit or sending an alarm in case the location of the goods is not consistent with the planned route data in the intelligent goods
- Communicate with the intelligent goods environment, e.g. equipment at terminals or equipment on-board the transport means

The intelligent goods

The intelligent goods role will be performed by the On-Goods Equipment [5] and sensors etc. fixed to the goods (transport item). The role can be seen to belong both to the supply chain and transport systems role models or it could be seen as an independent role outside the two roles models interacting with the different roles in the two domains.

THE INTERSECTION OF THE ROLE MODELS

By comparing the responsibilities of the roles in the transformed supply chain reference model and the transport reference role model it is evident that there are several intersections between the supply chain domain and the transport domain from a role model point of view. The table below shows the mapping of the two sets of roles and responsibilities describing how each of the roles in the supply chain reference model intersects with roles in the transport system reference model.

Table 1: Intersections between roles in the supply chain (SC) and transport system reference models

Supply Chain (SC)		*Transport systems*	
Role	**Transport related SC responsibilities**	**Matching ARKTRANS responsibilities**	**Role**
 Planner	Specify Source requirements related to transport and establish sourcing transport plans Specify Deliver requirements related to transport and establish delivery transport plans Specify Return requirements related to transport and establish transport plans	Defining the transport demands and requirements including the object, e.g. the cargo item, to be transported Transport planning and re-planning (finding the best transport alternative, i.e. the best transport services)	 Transport User
 Purchaser	Implement the sourcing transport plans Schedule Product Deliveries Receive Product	Defining the transport demands and requirements including the object, e.g. the cargo item, to be transported Transport follow up, e.g. track and trace an object in the transport system	 Transport User
 Deliverer	Implement the delivery transport plans Determine delivery date, consolidate orders and build loads Route shipments and select transport service providers (carriers) and rate shipments Pack product, load product and generate shipping documents Ship product Receive and verify product by customer	Defining the transport demands and requirements including the object, e.g. the cargo item, to be transported Transport planning and re-planning (finding the best transport alternative, i.e. the best transport services) Transport follow up, e.g. track and trace an object in the transport system	 Transport User
 Returner	Implement the Return transport plans Schedule Product shipment Return Product Receive Product	Defining the transport demands and requirements including the object, e.g. the cargo item, to be transported Transport follow up, e.g. track and trace an object in the transport system	 Transport User

The table shows that the supply chain Deliverer role has the same responsibilities as the Transport User. This implies that from a role and responsibility point of view, a Deliverer in a supply chain becomes a Transport User in the transport system role model. However, all the roles in the supply chain model perform one or more of the responsibilities of the Transport User. Hence, from an object-oriented point of view one could say that all the supply chain roles belong to the Transport User Class.

THE COMPLETE ROLE MODEL FOR INTRANS

Figure 5 shows the complete role model for INTRANS and how the supply chain domain and transport domain intersect with each other. It is shown in Table 1 that all the SCOR roles as defined in this paper (except the Producer) become Transport Users in the ARKTRANS role model for the transport domain. The Deliverer role covering the Deliver operations in the SCOR model will be the supply chain management role that completely matches the Transport User role as defined in the ARKTRANS reference model.

The Intelligent goods role is shown as a role between the supply chain domain and the transport domain as the role is performed by an object that will be transferred between these two domains several times during its lifecycle from production to final delivery to the final customer. By looking at the responsibilities of the Intelligent goods one could say that the Intelligent goods could also be described as a Transport User in those cases where the Intelligent goods has the information and artificial intelligence to find the best transport service and/or to follow up the transport. However, in this paper the Intelligent goods has been kept as a separate role to differ between the two roles Intelligent goods and Transport User enabling a more detailed definition of the role Intelligent goods being one of the crucial objects in the focus area intelligent goods in intelligent transport systems.

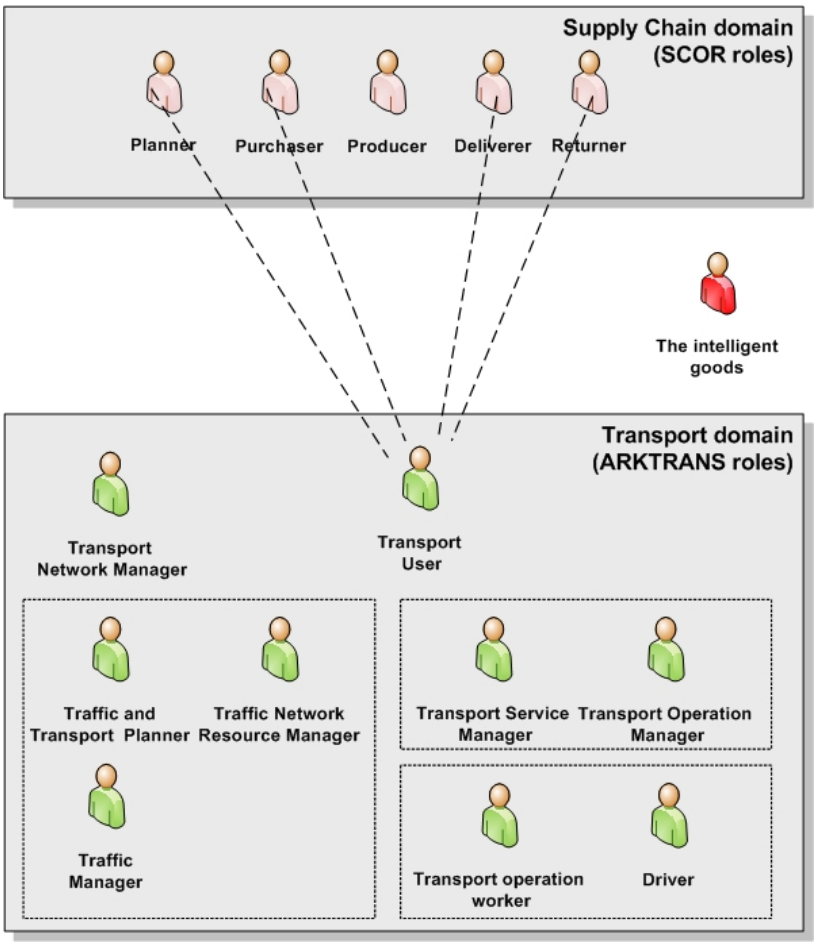

Figure 5: The complete role model for the INTRANS project

HIGH LEVEL INFORMATION ARCHITECTURE

Figure 6 shows the high level information architecture. The information flows are for simplicity limited to the interface between the supply chain domain and the transport domain and the interfaces between the intelligent goods and the two domains. The description of the information flows is also on a high level as the information flows will be further defined based on the requirements from all the roles involved in the interface between the supply chain domain, the transport domain and the intelligent goods.

The **Network information** flow includes information about the available transport networks that may be used for transport of goods in the supply chain.

The **Traffic information** flow includes information needed for finding the best transport service where availability, capacity and reliability are important attributes. Traffic information is also needed for monitoring the transport of the item in the transport system, e.g. for arrival time prediction.

The **Goods data and transport service data** flow includes several types of data needed and used in different ways by many of the roles in the supply chain and transport system management. First of all it will include data about the goods itself, as a minimum a unique identification. It may also include specific attributes describing the type of goods, e.g. hazardous goods, and it may also include attributes describing certain limits or values that should not be exceeded during the transport, e.g. temperature. Secondly the information flow may include information about the transport service, e.g. origin – destination data, nodes and links in the transport infrastructure, terminals, time schedule etc enabling the intelligent goods and other roles communicating with the intelligent goods to monitor the transport service by comparing planned data with real and/or achieved data.

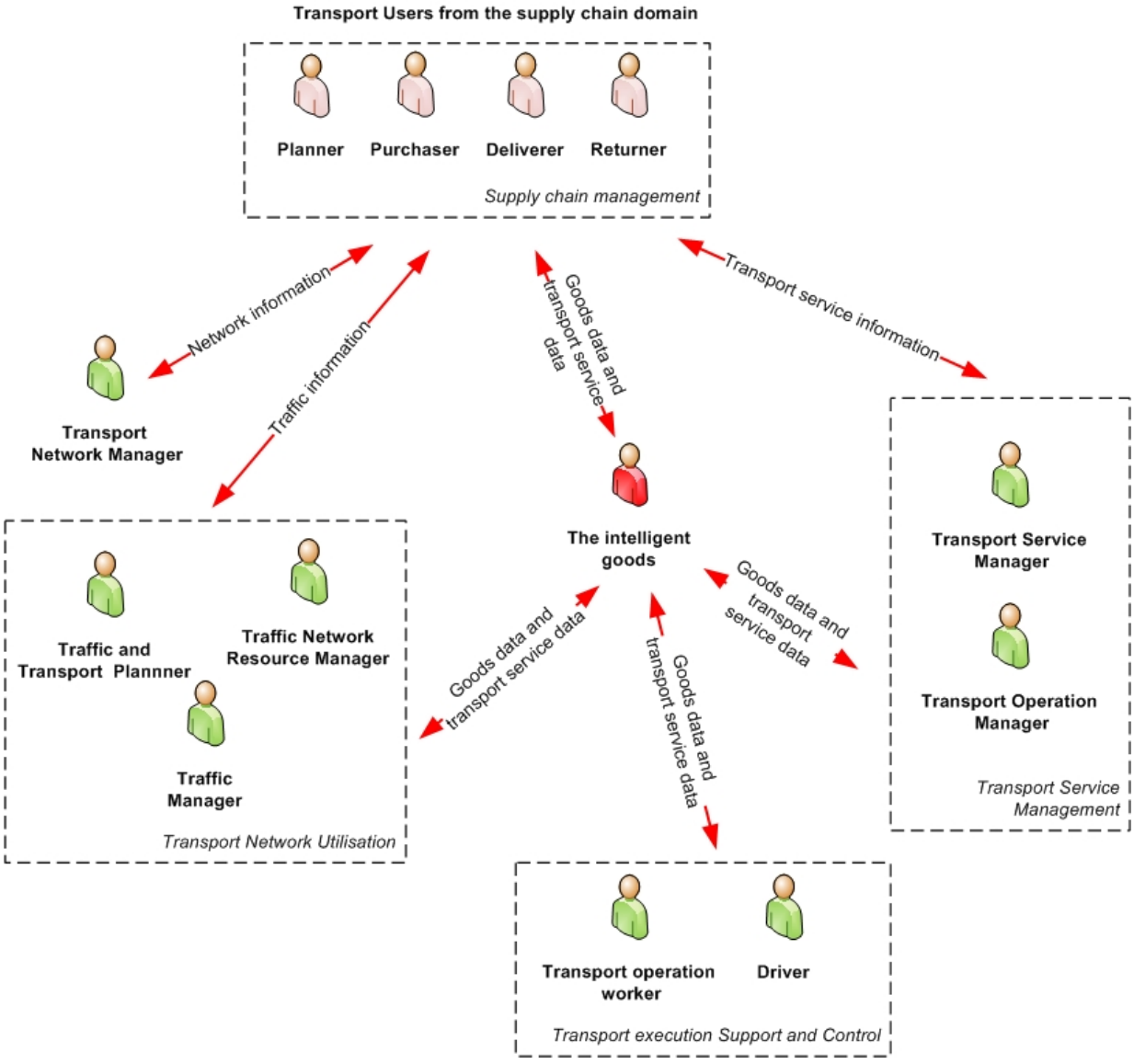

Figure 6: High level (and limited) information architecture for INTRANS

The data stored in the intelligent goods is one of the major issues and the intelligent goods should always be able to protect the data stored against unauthorised changes. Another major issue is to what extend shall the intelligent goods represented by the on-goods equipment, be able to manage and handle the data that are stored, i.e. how much intelligence shall be transferred from the back-office systems to the intelligent goods itself.

The **Transport service information** flow includes data about the transport service enabling the Transport service management roles to handle the transport demand from the Transport User. It also covers information from the Transport Service management to the Transport User about transport services available as well as contractual information between the Transport User and the Transport Service management roles.

CONCLUSIONS

This paper describes how the Supply Chain (SC) management process model defined in SCOR may be matched with the multimodal system architecture, high level role model for transport systems defined in ARKTRANS. By transforming the process model in SCOR to a role model, the matching is done by comparing responsibilities in the role model for SCOR and the role model in ARKTRANS. The matching describes the different intersections between the SC domain and the transport domain and how the terminology in the SCOR model representing the SC domain may be mapped with the terminology in the transport domain model defined in ARKTANS. Hopefully this will contribute to a better understanding of the different terminology used in the SC and transport domains and bridge the two domains in a way that enables a better communication between experts from the two domains.

REFERENCES

[1] Supply-Chain Council: www.supply-chain.org
[2] ARKTRANS: www.arktrans.no
[3] SMARTFREIGHT: www.smartfreight.info
[4] The Smartfreight Architecture, Draft version 26 June 2008, Marit Natvig, Hans Westerheim and Geir Frode Skylstad, SINTEF
[5] Intelligent goods in Intelligent Transport System, Scientific paper presented at the ITS World Conference 2008, Trond Foss, June 2008, SINTEF